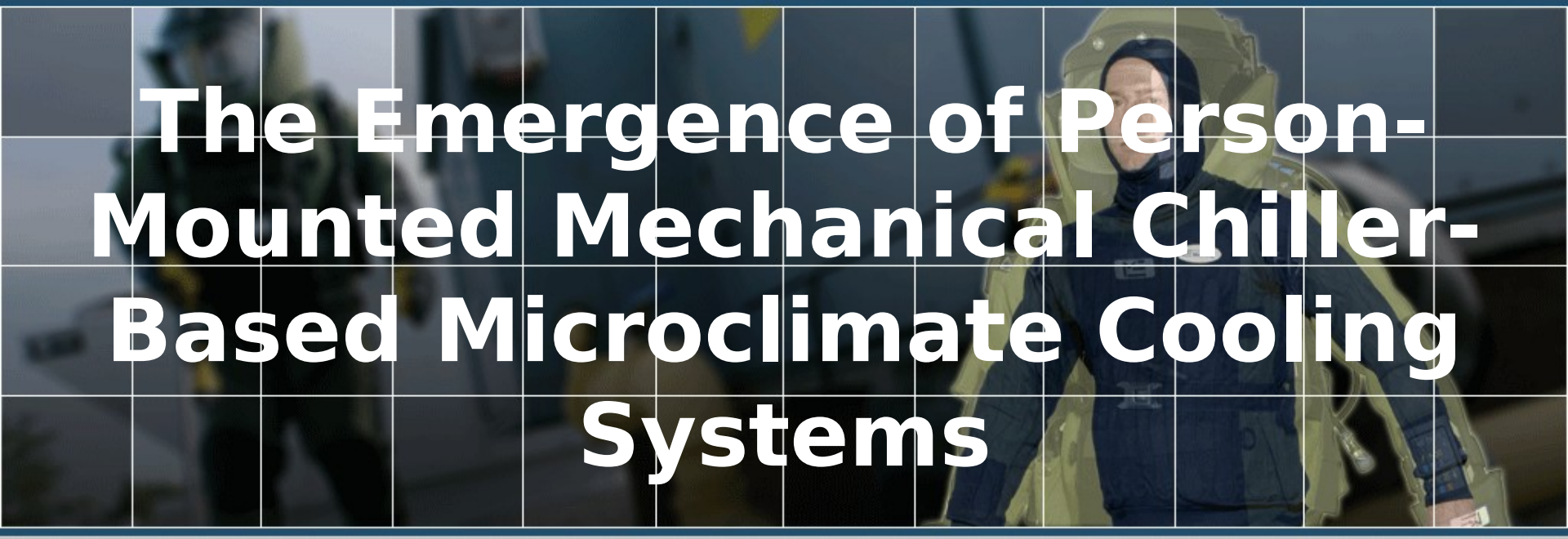


The Emergence of Person-Mounted Mechanical Chiller-Based Microclimate Cooling Systems

Med-Eng™

Aspen Systems Inc.

Kevin Semeniuk, Jinkai Wang, and Kirk Dobbs

Tim Membrino and Glenn Deming

International Soldier Systems Conference, December 2004, Boston M.A.

Primary Threats

- Ballistics
- Explosives
- Chemical/ Biological
- Environmental
- Metabolic Requirements

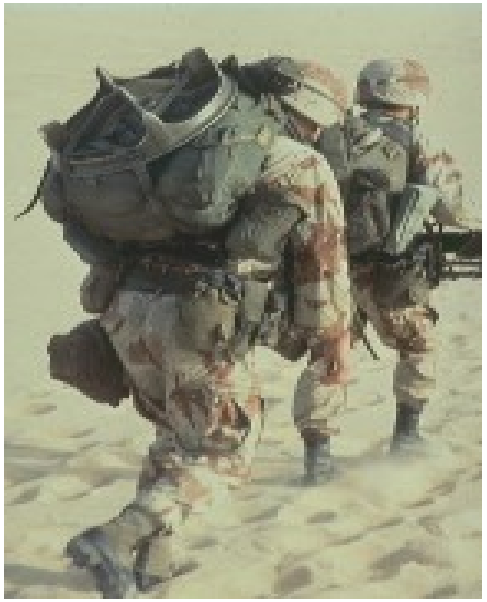
Secondary Threat

Heat Stress

Personal Protective Equipment

Increased risk of ***heat stress*** due to…

- Thermal Resistance
- Moisture Resistance
- Physical Burden

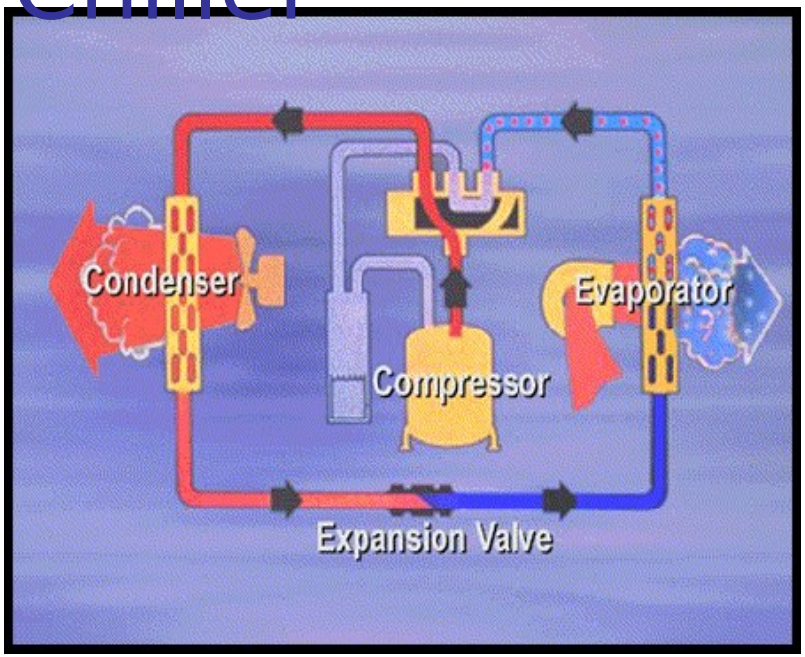


Controlling Heat Stress

Microclimate Cooling Systems

- Internal physiological heat removal
- Reduced effect of external environmental heat

Miniaturized Vapor Compression Chiller



- Reliable and widely used
- Ground-based, vehicle or man-mounted
- Mature technology

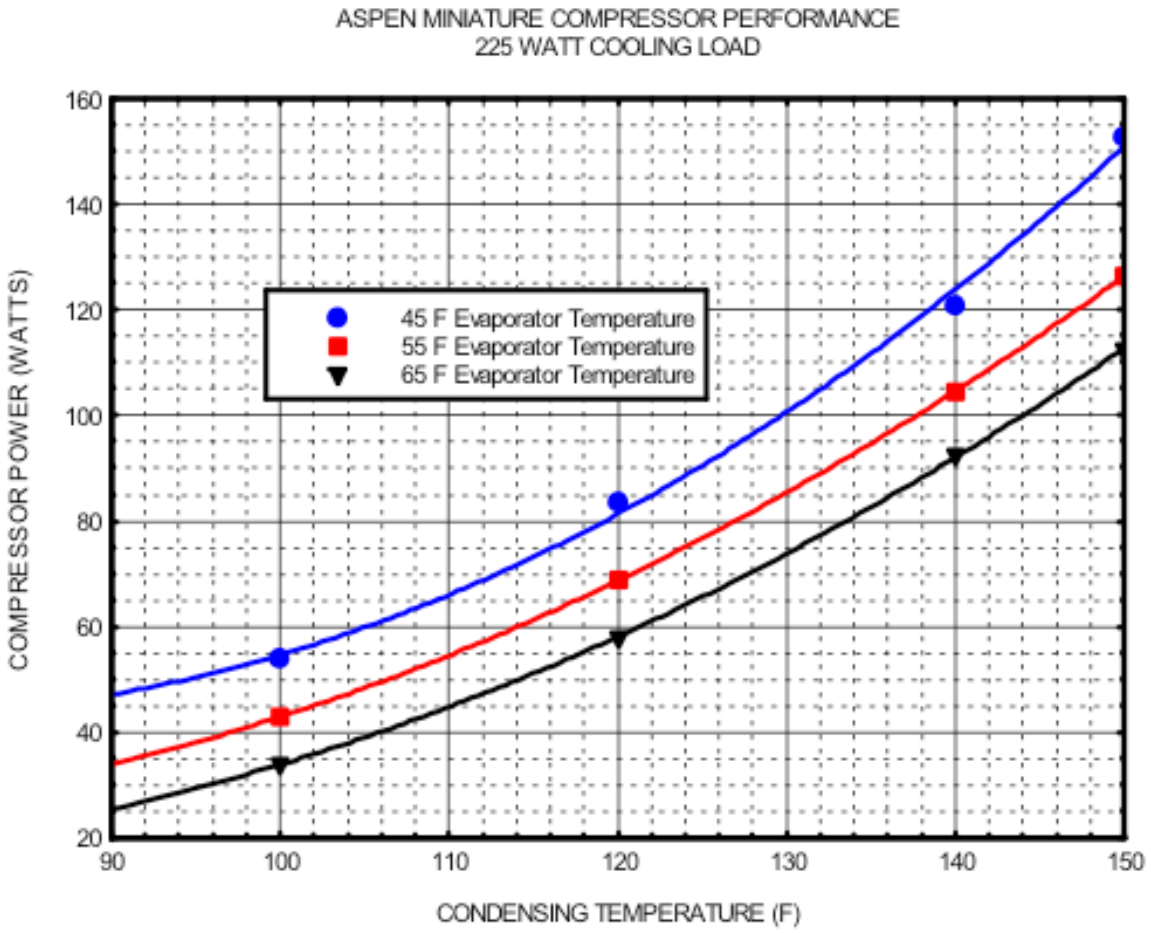
∀↑ mission length

- Physiological benefits

Miniaturized Compressor

- Rolling piston rotary compressor
- Hermetically sealed
- Volume – 11 in^3
- Weight – 1.3 lbs
- Capacity > 1,500 Btu/hr

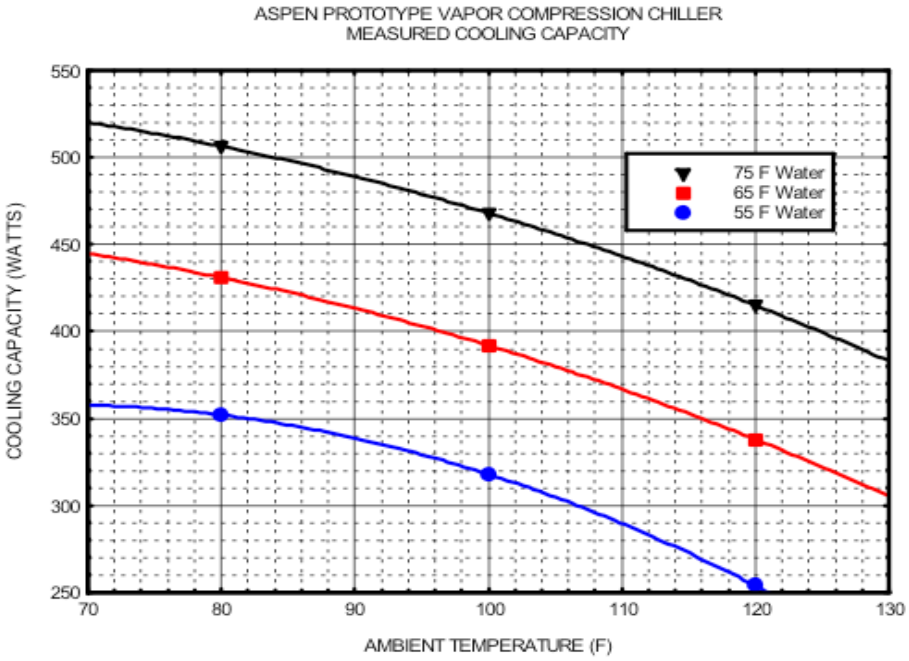
Compressor Performance

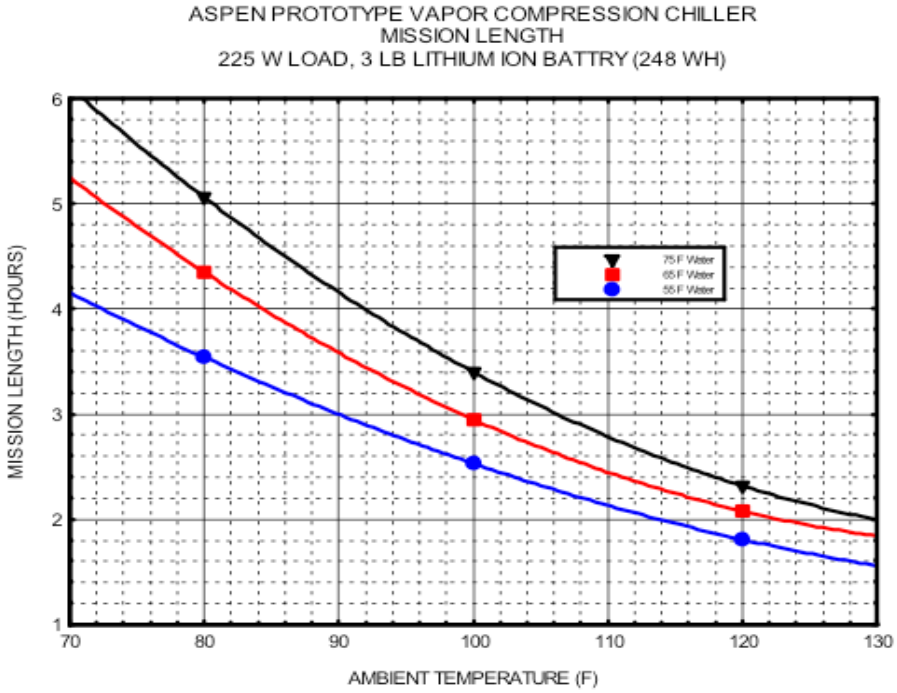


Man-mounted VCC System

Specification	Value
Weight	6 lbs (without batteries)
Volume	233 in^3
Dimensions	9.5 (H) x 7.0 (W) x 3.5 (L)
Cooling Capacity	150 – 500 W
Configuration	Backpack, hip or thigh mount
Flow Rate	~500 ml/min
Operating Temperature	80 – 120˚F
Delivery Water Temperature	Variable from 50 to 75˚F

Man-mounted VCC System





Vapor Compression Chiller

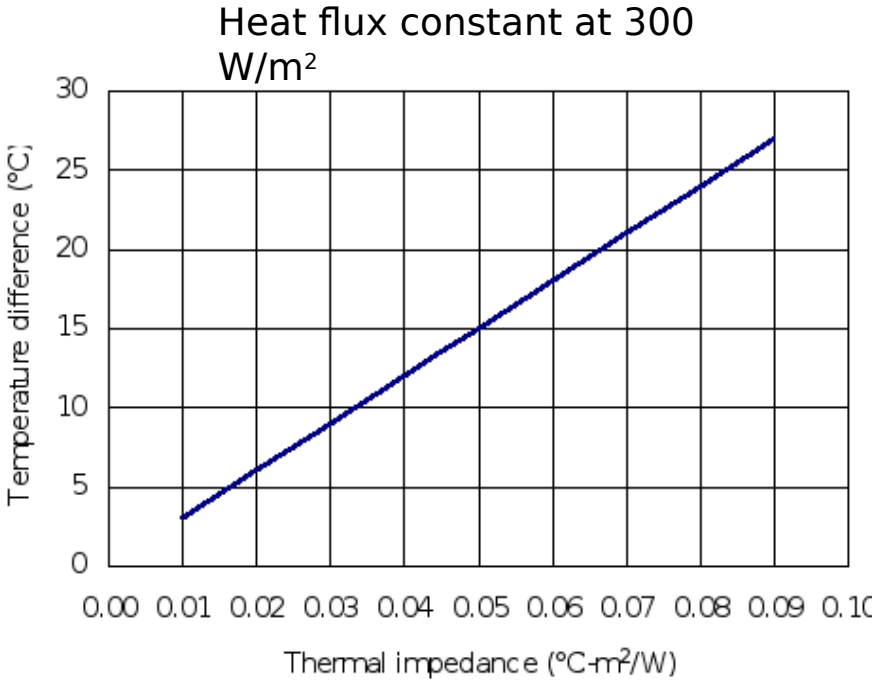
- Temperature regulated control
- Variable cooling capacity
- Removes logistical burden of replacing/ regenerating cooling source with ice/phase change based systems

LCG Tubesuit

- Key source of heat transfer with the body (conduction, convection)
- Applicable to all liquid-based MCS

↑ LCG Tubesuit Performance

1. ↓ thermal impedance between the cooling liquid and the body
2. ↓ flow resistance in the LCG Tubesuit



LCG and Chiller Performance Effects

LCG Tubesuit

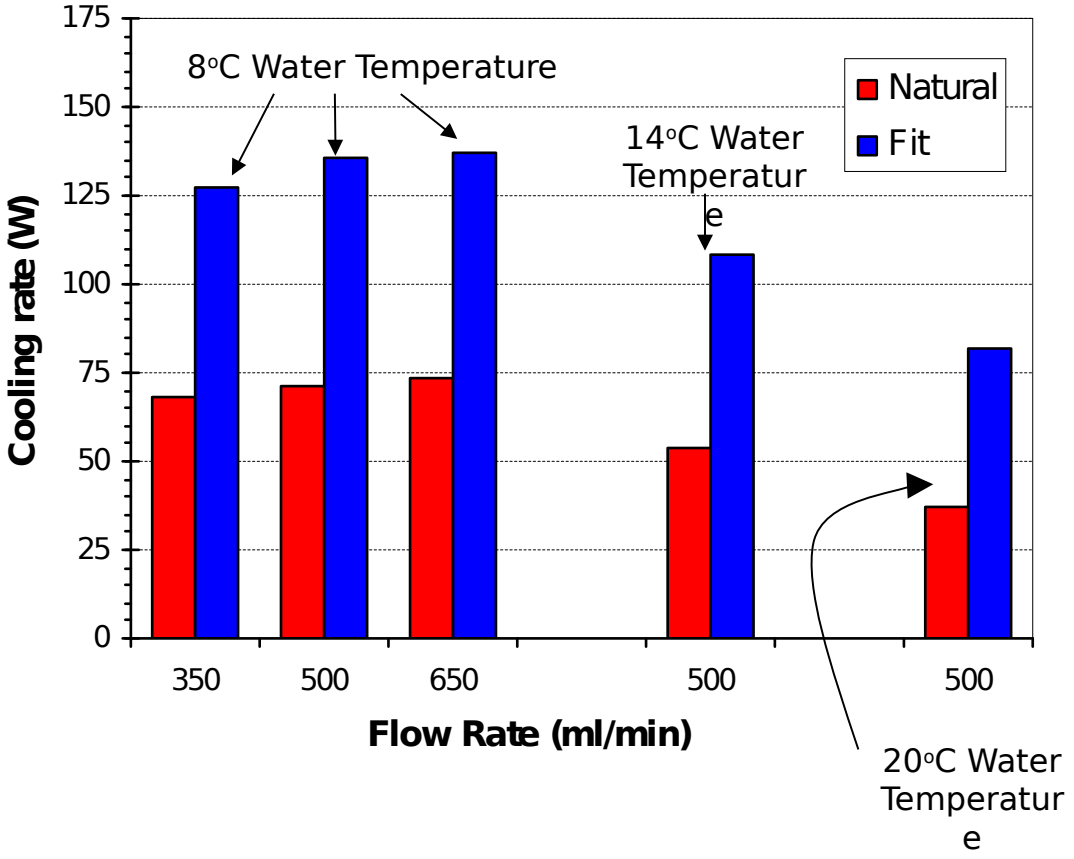
↓ Thermal Impedance → ↓ Temperature difference → ↑ Circulating fluid temperature

Vapor Compression Chiller

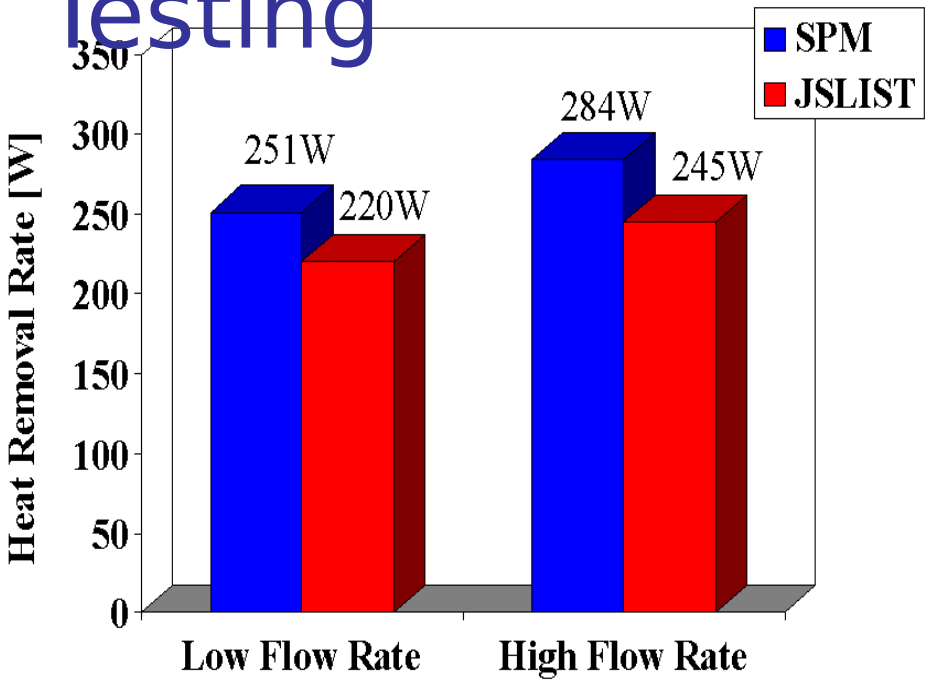
- ↑ Evaporating temperature
- ↓ Difference between evaporating and condensing temperatures
- ↓ Power consumption of compressor
- ↑ Coefficient of Performance
- ↑ Cooling capacity of chiller
- ↑ Latent heat of evaporation of the refrigerant

Other Key LCG Variables

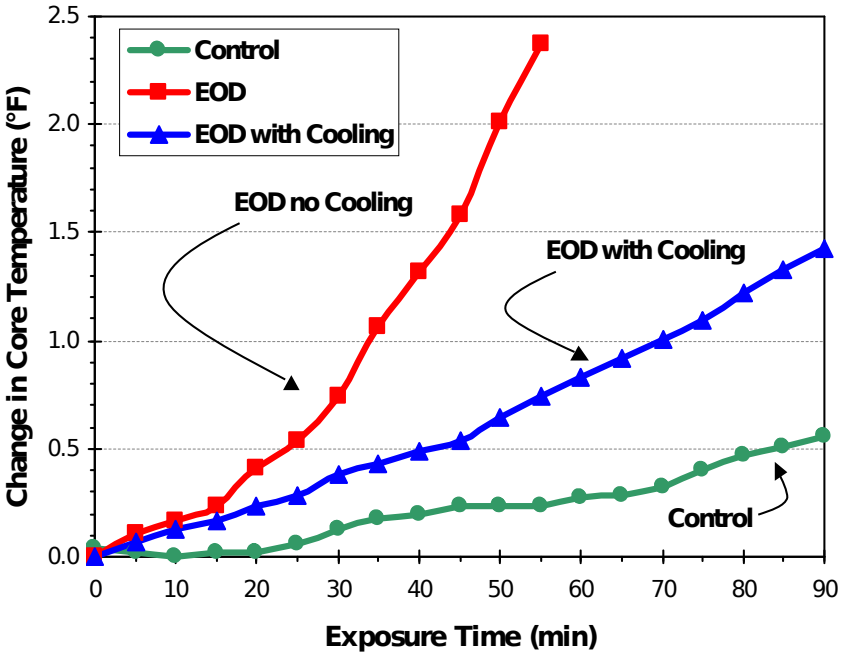
- Fit
- Tubing density
- Pump power
- LCG materials



Microclimate Cooling System Testing



Thermal Manikin Testing at U.S. Army Natick



Physiological Testing at the University of South Florida

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